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A model of cluster adoption: The role of resource characteristics and technology

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ABSTRACT

Clusters are groups of separate firms that collaborate for business purposes. They are an important government strategy to increase economic development. Government agencies attempt to provide the initial impetus for clusters to develop. These agencies base their programs on reviewing naturally occurring clusters (clusters that develop without government intervention), the advice of cluster consultants, and relevant theory (for example, Porter, 1998; Porter, 2000). The success of these government initiatives has been mixed. This paper examines the factors that affect cluster adoption by developing a model based on the theories of innovation diffusion and the resource-based view of the firm. The research model was tested using a survey-based approach. The results indicated that relative advantage, as measured by resource value, immobility, and heterogeneity, has a positive effect on the extent of cluster adoption. Use of information and communication technologies and complexity were found to affect relative advantage. Cluster compatibility was found to reduce the perceived complexity of clusters. The results imply that future innovation-diffusion research should consider the effects of innovation attributes on each other, as well as innovation adoption. The paper also affects practice. It provides guidance to consultants and government agencies on how to formulate strategies to increase cluster adoption.

Keywords: clusters, adoption, innovation diffusion, resource-based view.

1. INTRODUCTION

Clusters are “geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate” (Porter, 2000, p.16). This definition highlights the key success factor of clusters, that is, achieving a balance between competition and cooperation. While the benefits of competition derived from the close proximity of cluster firms is likely to be automatic, many cluster firms require some form of intervention for effective cluster cooperation - “Although the existence of a cluster makes such relationships more likely to develop and become effective, they are far from automatic. Formal and informal organizing mechanisms and cultural norms often play a role in the functioning and development of clusters,” (Porter 2000, p.21).

The objective of this paper is to identify what factors affect the extent of cluster adoption. I use innovation diffusion theory to help explain clusters adoption because clusters represent an innovation for many firms. Clusters represent a new way of thinking and many managers are initially wary of them (Porter, 1998, p.256). While most diffusion research in the information-systems domain has focused on technological (tangible) innovations, innovation diffusion theory applies equally to intangible innovations such as ideas or communication (Rogers, 1995, p.75). There have also been studies in the information systems field that focused on intangible aspects in addition to technology. One example is the study of business process reengineering (the intangible aspect) in conjunction with electronic data interchange adoption (Iacovou et al., 1995; Ramamurthy et al., 1999).

For the purposes of this paper, cluster adoption occurs when a firm cooperates on one or more transactions with other cluster members or the cluster performs certain transactions on behalf of its members. The transactions that it undertakes vary. It may be used as a vehicle for group purchasing for its members, or it may be a marketing vehicle to consumers, or it may leverage the knowledge of its members to then sell to consumers (Markus, 2000). Coordination of the cluster is often achieved by using information technologies such as the World Wide Web, E-mail, and intranets.

One example of a cluster is the education cluster based in Cairns, Australia. Its members include many schools and English language institutions that compete for international students. They currently cooperate in some marketing areas. The cluster has a website that jointly markets

cluster members to international students. Many cluster members, however, have agents in overseas locations that work exclusively for that cluster member.

To summarize, my research questions are:

1. Do innovation-diffusion characteristics affect the relative advantage of cluster adoption?
2. Does the use of information and communication technologies affect cluster relative advantage?
3. Does relative advantage, as measured by resource characteristics derived from the resource-based view of the firm, affect cluster adoption?

I tested the research model using case-study and survey data from Australian and New Zealand clusters. Only survey results are reported in this paper due to space limitations. The results indicated that relative advantage has a positive effect on the extent of cluster adoption, suggesting that resource value, immobility, and heterogeneity are relevant measures of cluster relative advantage. The results also support the negative relationship between complexity and relative advantage. Communication technologies were found to positively influence relative advantage. In the revised model (discussed in section 4), the results also indicated a negative relationship between compatibility and complexity. Contrary to predictions, compatibility was found to positively affect result demonstrability and visibility. The predicted relationships between result demonstrability, visibility, trialability, and complexity were not significant.

1.1 Motivation and contribution

The development of a cluster-adoption model is driven by theoretical and practical objectives. From a theoretical perspective, this paper attempts to extend innovation diffusion research by examining the interactions of the innovation characteristics. There is little or no information-systems research on the interrelationships among innovation attributes. For example, a potential adopter's perception of relative advantage is likely tempered by their knowledge of successful results, observing other successful clusters, and their perception of the complexity of the innovation. Information-systems research based on the Theory of Planned Behavior or the Technology Acceptance Model provides some support for this motivation (Taylor and Todd, 1995). These studies show that perceived ease of use (complexity) affects technology acceptance indirectly through perceived usefulness (relative advantage).

The other theoretical motivation of this paper is to provide empirical evidence on the factors that affect cluster adoption. Substantial research exists on electronic data interchange (Iacovou et al., 1995; Raymond and Bergeron, 1996; Jones and Beatty, 1998; Ramamurthy et al., 1999) and firm cooperation (Buckley and Chapman, 1998), both of which often exist in clusters. Current research is mainly descriptive and emphasizes that clusters are created to share and combine resources for mutual benefit (Porter, 2000; (Kisielnicki, 1998; Strader et al., 1998; Fariselli et al., 1999). It does not analyze or empirically test the factors necessary for cluster adoption (Venkatraman and Henderson, 1998). Other cluster research focuses on only one potential benefit of a cluster, such as agility (Campbell, 1998), without considering additional potential benefits.

This study will help managers decide whether a cluster will improve their firm's outcomes and what transactions should be performed by the cluster. Government state development agencies in numerous countries have invested considerable funding and effort to initiate clusters. They believe that clusters are an important method for small businesses to remain competitive and enter new markets. For consultants and government agencies, the model provides guidance on how to facilitate the adoption of clusters by small firms.

The remainder of the paper is structured as follows. Section 2 develops the propositions. Section 3 details the research method to be used to test the model. Section 4 presents the results of the survey. Section 5 discusses the limitations and conclusions of the paper.

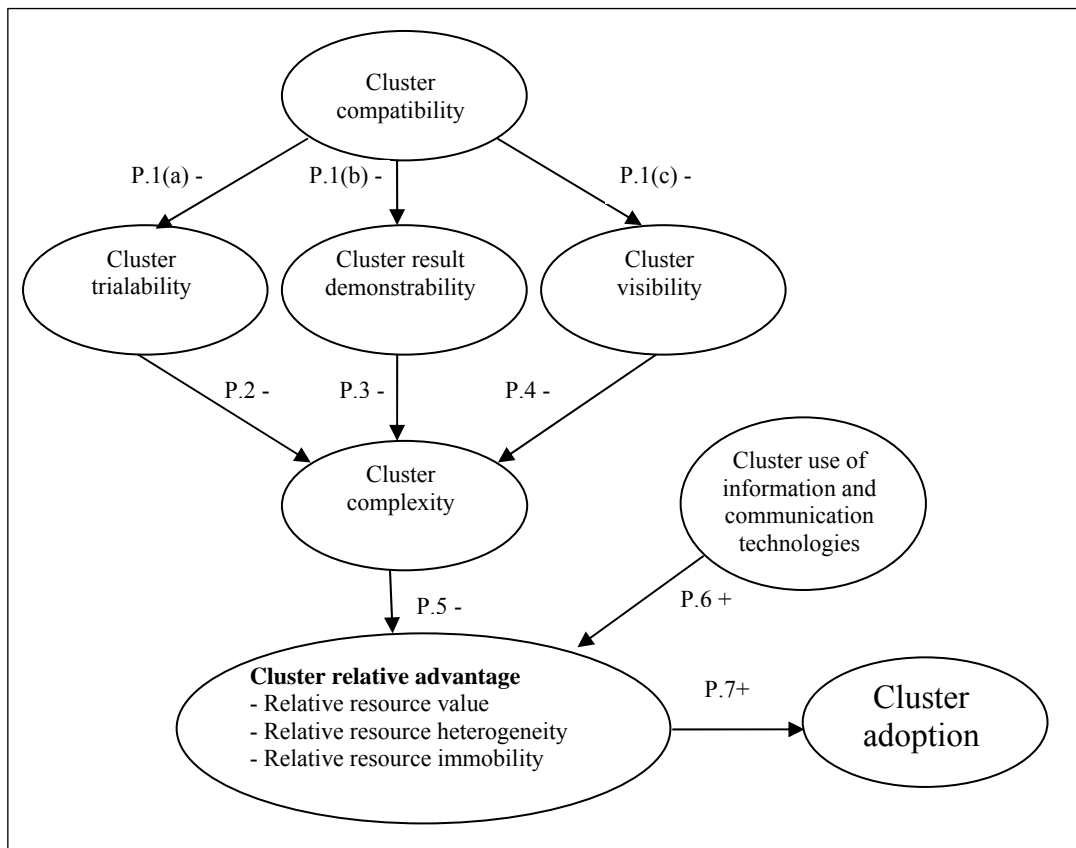
2. PROPOSITION DEVELOPMENT

Figure 2.1 presents my model of cluster adoption. It also shows the number and direction of each proposition indicated by the model. The following sections discuss each proposition.

2.1 Compatibility

Compatibility “is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters” (Rogers, 1995, p. 224). Relevant values and beliefs for cluster adoption include the belief in the benefits of cooperative organisation and the belief in the benefits of information technology. Past experiences with technology or co-operatives also influence compatibility. If these relevant beliefs and experiences are positive, they are likely to increase the extent of cluster adoption.

Figure 2.1: Research model for cluster adoption (including proposition numbers and direction)



Most studies accept (usually implicitly) that the innovation-diffusion factors are independent (Tornatzky and Klein, 1982; Moore and Benbasat, 1991; Agarwal and Prasad, 1997; Karahanna et al., 1999). As I described in the motivation section, I believe that these factors are not independent. The consequence of this factor dependence is that compatibility does not directly influence cluster adoption in the research model. It influences adoption indirectly through visibility, trialability, and result demonstrability (these factors also have indirect effects on adoption). The reasoning is that the closer a new innovation is to the past experiences of a potential adopter, the less likely that a potential adopter will require other sources of positive information about the innovation. These positive information sources include trialling the new innovation, seeing other innovations in action, and acquiring information from peers and consultants about the positive results from adopting the innovation. This analysis leads to the first three propositions:

Proposition 1a: The extent of compatibility of the cluster with potential adopters is negatively related to the extent of trialability.

Proposition 1b: The extent of compatibility of the cluster with potential adopters is negatively related to the extent of result demonstrability.

Proposition 1c: The level of compatibility of the cluster with potential adopters is negatively related to the extent of visibility.

2.2 Trialability

The level of trialability of an innovation is the extent to which an adopter is able to experiment successfully with the innovation before committing to its adoption (Agarwal and Prasad, 1997; Karahanna et al., 1999). If potential parties to a cluster are able to experiment with a limited number of transactions at low cost, they are more likely to adopt the cluster. As described in the section on compatibility, the requisite level of trialability is affected by the degree of compatibility. The greater the past experiences of the potential adopter with other clusters, the less likely the requirement for trialability. Trialability is also predicted to indirectly affect adoption through complexity. I predict that the greater the ability to trial the cluster, the lower the perceived complexity. Successfully trialling the cluster reduces uncertainty and allows for a gradual adoption of the cluster. This analysis leads to the second proposition:

Proposition 2: The extent of trialability of the cluster available to potential adopters is negatively related to the extent of perceived complexity.

2.3 Result demonstrability

Adoption of a cluster is more likely if the results of adoption are easily demonstrated to potential adopters (Moore and Benbasat, 1991; Moore and Benbasat, 1996; Agarwal and Prasad, 1997). Change agents (e.g., consultants) who are able to show definitively the results of adoption increase the likelihood of adoption. Innovations that exhibit high result demonstrability also allow a potential adopter's peers to demonstrate the results. This outcome is important because a potential adopter is more likely to listen to a peer than an external change agent (Rogers, 1995).

Result demonstrability also affects adoption indirectly through complexity. The greater the ability to demonstrate the positive benefits and ease of adoption of clusters, the less likely potential adopters perceive that adopting a cluster is complex. Adopters are likely to feel more certain that their own cluster will achieve positive results. This analysis leads to the third proposition:

Proposition 3: The extent of result demonstrability of the cluster for potential adopters is negatively related to the extent of perceived complexity.

2.4 Visibility

Visibility is the degree to which the innovation is amenable to sight (Moore and Benbasat, 1996). Potential adopters are able to see highly visible innovations in use, providing a concrete indication of their worth. A cluster has both visible (hardware) and invisible (software) attributes (Rogers, 1995). The visible attributes include a cluster office and website. The invisible attributes include cooperation among cluster members. If cluster members are able to view the visible attributes in use by other clusters it is likely to positively influence the adoption decision.

Visibility also indirectly affects adoption through complexity. If potential adopters see other successful clusters, especially in closely related industries, they are less likely to believe that cluster participation is difficult. This analysis leads to the fourth proposition:

Proposition 4: The extent of visibility of the cluster by potential adopters is negatively related to the extent of perceived complexity.

2.5 Complexity

Innovations vary in the level of difficulty associated with their adoption. An innovation that is perceived to be difficult to understand or not easy to use reduces the likelihood and extent of adoption (Hoffer and Alexander, 1992). Cluster adoption requires both business and information systems expertise, making it a complex innovation. Possible difficulties include obtaining sufficient cooperation between cluster members, deciding on cluster goals and boundaries, and successfully implementing the required information and communication technologies.

As discussed in the previous three sections, the extent of perceived complexity is mitigated by obtaining positive information about clusters from various sources. These sources include trialling cluster transactions, obtaining positive information about other clusters, or physically seeing other transactions in action.

I believe that complexity is important in determining the relative advantage of clusters rather than directly affecting cluster adoption. Complexity is likely to be associated with increased costs to overcome any difficulties and increased risks of not achieving desired cluster benefits. The more complex a cluster is perceived, the less likely those potential adopters will perceive a sufficient relative advantage to adopt the cluster. The technology acceptance model

provides support for this reasoning with its prediction of a relationship between ease of use (complexity) and usefulness (relative advantage) (Taylor and Todd, 1995). Alternatively, it may reduce the extent of adoption to only those transactions not perceived as complex. This analysis leads to the fifth proposition:

Proposition 5: The extent of perceived complexity of the cluster by potential adopters is negatively related to the extent of perceived relative advantage.

2.6 Cluster use of information and communication technologies

Cluster theory posits that information infrastructure is an important factor (input) condition for cluster competitive advantage (Porter, 1998, p.211). In addition, it suggests that any upgrading or improvement of the cluster requires better data and communication infrastructure (Porter, 1998, p.257). I believe it follows that information and communication technologies, such as intranets, extranets, The World Wide Web, E-mail, GroupWare, and satellite links, enable clusters to function effectively. Research on virtual organizations, a similar form of collaboration to clusters, supports this hypothesis (Kisielnicki, 1998; Strader et al., 1998).¹

Without information and communication technologies, many transactions can not be conducted efficiently by a cluster. The use of information and communication technologies reduces coordination costs through their ability to reduce the cost of exchanging and processing information (Clemons et al., 1993). They also lessen the risk of opportunism by acting as a monitoring mechanism of other firms in the cluster (Brynjolfsson et al., 1994).

An example is a cluster comprising tourist-dependent firms within a particular geographic region formed to share timely tourist information. The cluster's members are able to tailor their products and services to the particular tourists in the area at that time. To collate and distribute this information in a timely and cost-effective manner requires information and communication technology such as a secure Web site or regular e-mail updates. Other examples include on-line ordering of related products from the cluster, a cluster Web site for customers, electronic payments, and traditional EDI functions.

The effectiveness of information and communication technologies depends on all firms within the cluster adopting the technologies. I predict that cluster adoption is a function of how

¹ Virtual organizations do not have the co-location requirement of clusters, so technology plays a more important role for virtual organizations compared to clusters. This difference may reduce the chance of finding a relationship between technology and cluster relative advantage.

widespread information and communication technologies are across the cluster. If all firms within the cluster do not adopt the technologies, their effectiveness is limited. Those firms not adopting similar technologies require other means of communicating and transacting, which increases coordination costs and the possibility of communication errors. Coordination between firms is more difficult, thereby increasing the costs of the cluster and diminishing the relative advantage of the cluster. This analysis leads to the sixth proposition:

Proposition 6: The extent of information and communication technology use is positively related to the extent of relative advantage of the cluster.

2.7 Relative Advantage

Relative advantage refers to the extent to which an innovation is perceived to improve the idea that it replaces (Rogers, 1995). Relative advantage takes a number of forms. The innovation represents a relative advantage if the adopter perceives that it increases profitability, social prestige, or savings in time or effort. Some researchers separate the social prestige or image component of relative advantage into a separate construct (Moore and Benbasat, 1991; Moore and Benbasat, 1996; Agarwal and Prasad, 1997; Karahanna et al., 1999). Relative advantage includes image in this paper for parsimony. I hypothesize that relative advantage is the sole factor directly affecting adoption because if the relative advantage is high enough, organizations will adopt clusters (or any other innovation) despite high levels of complexity or low levels of the other diffusion factors.

The concept of relative advantage is a general one. The following factors of relative advantage provide a more-precise measurement of the construct. These factors are relative resource value, relative resource heterogeneity, and relative resource immobility.

2.7.1 Relative resource value

The resource-based view of the firm identifies resources that give an organization a sustained competitive advantage (Hoskisson et al., 1999). To maintain a sustained competitive advantage, the theory posits that firms must control resources that are valuable, heterogeneous, and immobile (Barney, 1991; Mata et al., 1995).

Resources are widely defined to include “all assets, capabilities, organisational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness” (Barney,

1991), p. 101). A resource is valuable when it allows a firm to take advantage of an opportunity or minimise a threat (Hoskisson et al., 1999). For example, a firm that wants to enter an overseas market requires knowledge of that market. Knowledge is the valuable resource because it allows the firm to take advantage of the market opportunity. This knowledge may exist within the firm, or the firm may develop that knowledge, purchase the knowledge, or join a cluster to access that knowledge. Prior research reinforces the importance of valuable resources to cluster adoption (Keeble and Nachum, 2001). They found that knowledge exchange is one important resource in cluster development. Other potential valuable resources included a skilled labour force and access to transport infrastructure. No research model was presented in this prior research, however, to explain why these resources were important to the development of the cluster.

Identifying valuable resources is similar to the agenda-setting process described in innovation diffusion theory (Rogers, 1995, p.391) Agenda-setting involves identifying problems (a performance gap) within the organization. If the cluster resources are a solution to the performance gap then the adoption process is more likely to be triggered. Any firm that does not obtain access to more-valuable resources will not adopt the cluster. These valuable resources may exist already within one of the cluster firms (e.g., the knowledge of an individual cluster member), the resource may result from forming the cluster (e.g., reputation of a region for tropical foods), or the cluster may develop the resource (e.g., a cluster website). All of these resource sources are important for cluster adoption.

2.7.2 Resource heterogeneity and immobility

The other two factors of relative advantage are resource heterogeneity and resource immobility. The resource-based view of the firm predicts that the more heterogeneous and immobile a resource is, the more likely it is a source of sustained competitive advantage (Mata et al., 1995). Heterogeneous resources are those resources not possessed by competing firms. Immobile resources are those resources that are not easily replicated or substituted by other resources. Firms without the resource are at a cost disadvantage in acquiring or developing the resource compared to firms that already possess the resource (Mata et al., 1995).

For the individual firm, I hypothesise that the extent of relative advantage depends on the relative heterogeneity and immobility of the particular resource. If the individual firm does not obtain access to additional heterogeneous and immobile resources, then the cluster does not provide a relative advantage. Another perspective is that heterogeneous and immobile resources

are, by definition, difficult to obtain. Thus, collaborating with other firms within the cluster may be the only method of accessing the resources. This analysis leads to the seventh proposition:

Proposition 7: The extent of relative advantage of the cluster by potential adopters is positively related to the extent of cluster adoption.

3. RESEARCH METHOD

A combined mail and Internet survey was used to minimize any technology bias and increase the response rate for international respondents. Respondents could not submit the Internet survey without a valid respondent code, ensuring that an identified sample was maintained. The survey was distributed to the cluster representatives of 615 Australian and New Zealand firms. Table 3.1 shows the clusters surveyed and the number of members in each cluster. Cluster web sites or address lists provided by the cluster were the source for membership data.

Table 3.1: Description of clusters surveyed

Cluster	Location	Number of members	Members surveyed
AeroTeam	Ipswich, Queensland (QLD), Australia	34	28
Australian Tropical Foods	North QLD, Australia	288	38 ¹
Cairns InfoTech Enterprises	Cairns, QLD, Australia	89	77
Cairns International Education Providers	Cairns, Australia	16	13
Cairns Super-Yacht Group	Cairns, Australia	34	31
Creative Capital	New Zealand	18	17
Defense Teaming Centre	South Australia (SA), Australia	45	40
Earthquake Engineering	New Zealand	33	23
Electrical and Electronic Cluster	Logan, QLD, Australia	22	21
Electronics Industry Association	SA, Australia	120	85
Food Cluster	Logan, QLD, Australia	49	46
Healthy Ageing Industry Cluster	SA, Australia	30	7
Natural Hazards Cluster	New Zealand	26	15
Water Industry Alliance	SA, Australia	177	174
Total members		981	615
¹ The small percent of Australian Tropical Foods members surveyed was due to the isolation of members, the part-time nature of an infant industry, and substantial restructuring of the cluster at the time of the survey.			

Organizations with no cluster connection were not included in the sample. They do not have the requisite knowledge to assess the relative benefits and costs of clustering. Organizations that considered joining or joined initially and then withdrew were included in the sample, however, to increase internal validity. The questionnaire was addressed to the person responsible for cluster adoption within the organization. This person in most cases was the owner or senior manager of the organization. The organizations surveyed in this study are predominantly small firms. The cluster representative is therefore likely to have first-hand knowledge of all aspects of the business, including information technology issues. Results from case studies indicate that cluster representatives have sufficient knowledge to answer the survey items.

A pilot test of the 100 of the 615 cluster members was conducted. The purpose of this pilot test was to assess both the comprehension of the survey and to ensure that the Internet survey was accessible by all Web browsers. Seven responses were received, and a number of minor changes were made to the survey. The remaining 515 respondents were notified by e-mail and/or standard post two weeks later. Two follow-ups were sent, one three weeks after the initial mailing, the other six weeks after the initial mailing.

3.1 Construct development

All survey items were measured on a seven-point Likert scale ranging from strongly disagree to strongly agree or Not Important to Very Important, depending on the question. All survey questions included a not-applicable option to increase reliability.²

The innovation diffusion items were modified from existing diffusion scales (Moore and Benbasat, 1991; Moore and Benbasat, 1996; Agarwal and Prasad, 1997; Karahanna et al., 1999). Relative advantage was measured by using constructs derived from the resource-based view of the firm (Mata et al., 1995). The resulting questions are a combination of innovation diffusion theory and the resource-based view of the firm (i.e. “resources that allow my organisation to *more* effectively take advantage of a business opportunity”).

The survey items for cluster adoption are based on common activities identified from interviews with cluster members. The survey also included a section about the types of transactions performed by the cluster, their frequency, value, and importance. Most survey respondents could not answer this more-detailed section because most clusters are performing

² For a complete list of survey questions, please visit <http://www.uoregon.edu/~gcastner/clusters>

intangible activities such as information sharing as opposed to tangible activities that are easily valued. The results below only use the questions on common cluster activities to measure cluster adoption.

Interviews conducted with cluster members provided useful information for revising survey items. An expert panel comprised of academics reviewed the interview questions and their suggestions were also incorporated into the survey items. The flexible nature of the Internet survey required a substantial number of items per construct to account for the variations in respondent situations. These situations included stage of adoption (i.e. pre- or post-adoption) and extent of previous cluster experience (i.e. compatibility). The affected items exhibit only minor changes caused by these situational differences.

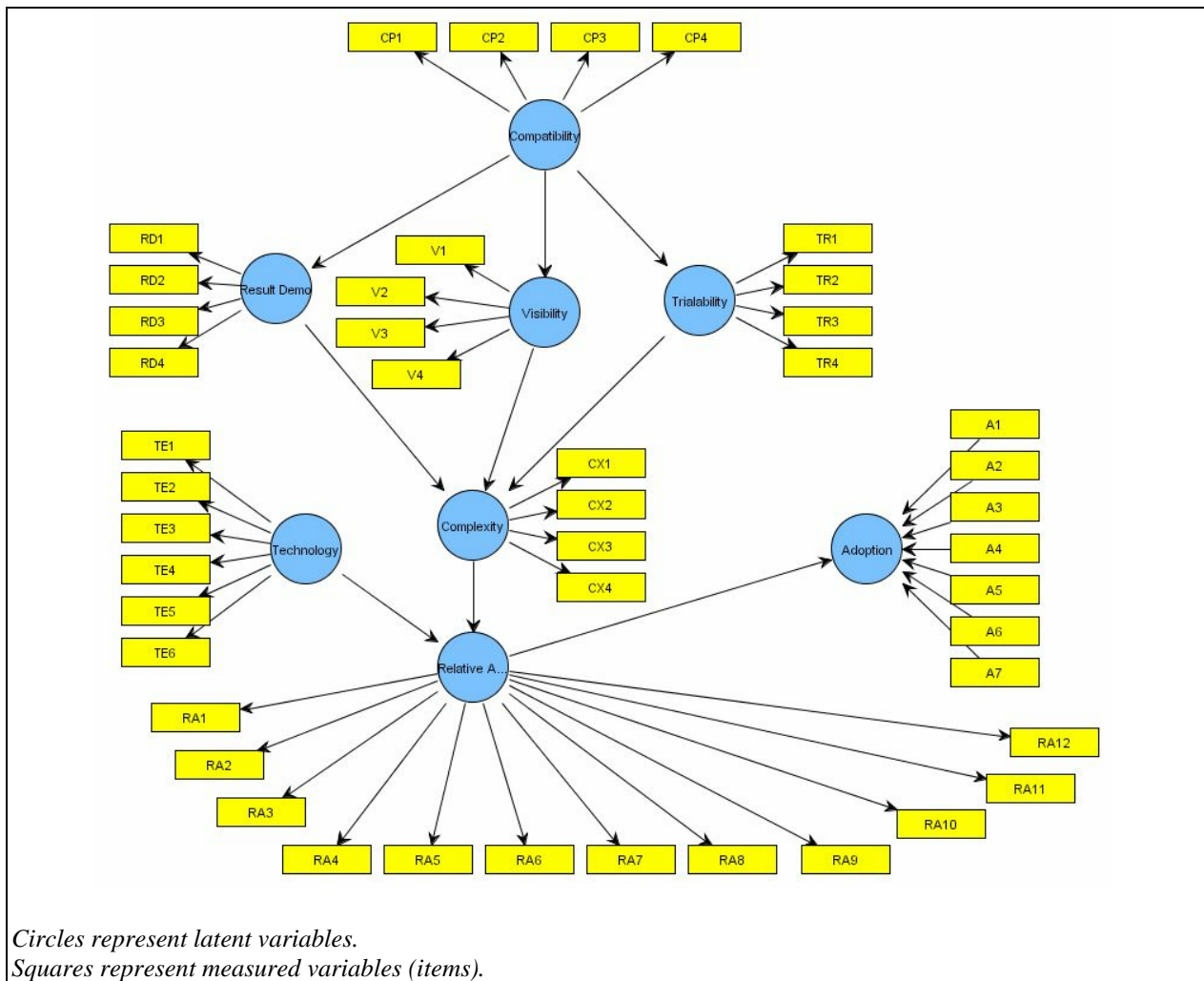
4. Results

This section provides the results of the analysis of the data collected. Section 4.1 details the procedures used to test the research model. The survey results for both the original and revised models are then presented.

4.1 Model Evaluation

Structural equation modeling (SEM), using partial least squares (PLS), is used to test the model in Figure 4.1. SmartPLS 1.01 was used to perform the analysis. The PLS approach is a non-parametric method that makes no distributional assumptions. It is appropriate for this analysis compared to covariance-based techniques (e.g. those used by LISREL) because of the small sample size. PLS model evaluation requires an assessment of predictive relevance, convergent validity of item scales, discriminant validity of item scales, and reliability of item scales. Predictive relevance is measured by R^2 (one for each dependent variable). The R -square measure is interpreted in the same way as in traditional regression. One limitation of PLS, however, is that it does not provide overall measures of model fit.

Figure 4.1: The combined structural and measurement model



4.2 Descriptive statistics

104 valid responses were received, representing a final response rate of 17 percent. The response rate is reasonable but does suggest the possibility of non-response bias. Table 4.1 shows the breakdown of the responses by cluster and survey type. There was a reasonably even distribution of response sources (56 paper and 48 web).³ Responses were classified as invalid if they were received from government entities (2 respondents), if there were greater than 6 missing responses (6 respondents), or if greater than 20 not-applicable responses existed (18

³ Sensitivity analyses were conducted using the revised model. Similar results were obtained when the sample was divided into paper-based and Internet-based respondents. The model was also tested excluding (separately) the Water Industry Alliance responses, non-active member responses, early responders, and late responders. The results remained substantially unchanged with the exception that some of the unpredicted positive associations between the diffusion constructs became insignificant.

respondents). The cut-off values are arbitrary but do not substantially affect the results. The high cut-off value and frequency of not-applicable responses reflects the wide variety of reasons organizations join clusters. Descriptive statistics for individual survey items are not reported because PLS makes no distributional assumptions about observed variables.⁴

Table 4.1: Final sample by cluster

Cluster	Total respondents	Invalid responses	Valid Web respondents	Valid paper-based respondents	Valid response rate (percent)
AeroTeam	8	1	4	3	25
Australian Tropical Foods	3	0	3	0	8
Cairns InfoTech Enterprises	11	3	6	2	10
Cairns International Education	4	1	1	2	23
Cairns Super-yacht Group	5	0	4	1	16
Creative Capital	4	0	4	0	24
Defense Teaming Centre	12	1	9	2	28
Earthquake Engineering	9	1	7	1	35
Electrical and Electronic Cluster	2	0	1	1	10
Electronics Industry Association	10	4	4	2	7
Food Cluster	5	1	3	1	9
Healthy Ageing Cluster	3	2	0	1	14
Natural Hazards Cluster	3	0	0	3	20
Water Industry Alliance	51	12	12	27	22
Total	130	26	58	46	17

4.3 Measurement model

Most item loadings are greater than the suggested threshold of 0.707 (Chin, 1998). More important, however, is that cross-loadings must be less than loadings. Items with lower loadings may be retained because they will still weight to the extent that they minimise residual variance. The requirement is that other, more-reliable indicators must exist ((Chin, 1998). Removal of these indicators should be guided by theory as well as statistical results (Chin and Todd, 1995).

The valid scales (see Table 4.2) omit CP2 and CP4, two indicators of compatibility. These two items focus on the importance of previous experience with clusters, rather than the mere existence of compatibility. These two items have low loadings and also received many not-applicable responses. CP4 cross-loads more highly on complexity than compatibility. CP2 and CP4 are therefore removed from further analyses. Similar reasoning supports the removal of

RD2, RD3, and V1⁵. CX4, TE4, TE6, RA2, and RA4 were removed because they do not load highly on their respective factors and their removal improves discriminant validity (AVE scores). Their removal does not substantially affect the structural model results.

The composite reliabilities (ρ_c) of the constructs, with the exception of result demonstrability, are all above the suggested threshold of 0.70 (Jöreskog, 1971). Before removal of the problematic items, AVE, a measure of reliability (Fornell and Larcker, 1981; Segars, 1994), is below the suggested threshold (0.50) for most factors except visibility and trialability. All squared correlations were below AVE both before and after removing the problematic items, indicating discriminant validity. Table 4.2 presents AVE for the valid item scales.

Table 4.2: Correlations of the latent variables (AVE in diagonals) – valid scales

	CP	CX	RA	RD	TE	TR	V
Compatibility	0.89						
Complexity	-0.27	0.53					
Relative Advantage	0.36	-0.36	0.54				
Result Demonstrability	0.30	0.06	0.20	0.86			
Technology	0.26	-0.18	0.27	0.18	0.61		
Trialability	-0.02	0.28	0.01	0.29	0.10	0.57	
Visibility	0.29	-0.01	0.17	0.53	0.12	0.36	0.73

Adoption was measured using formative indicators because the different activities used to measure adoption were not expected to be correlated and adoption is an effect rather than a cause of the indicator responses. A3 (information sharing) and A7 (accessing global markets) are the two significant indicators of cluster adoption. This result empirically suggests that accessing global markets and information sharing are the main indicators of the extent of cluster adoption for all clusters but other items still contribute to the adoption construct.

4.4 Structural model

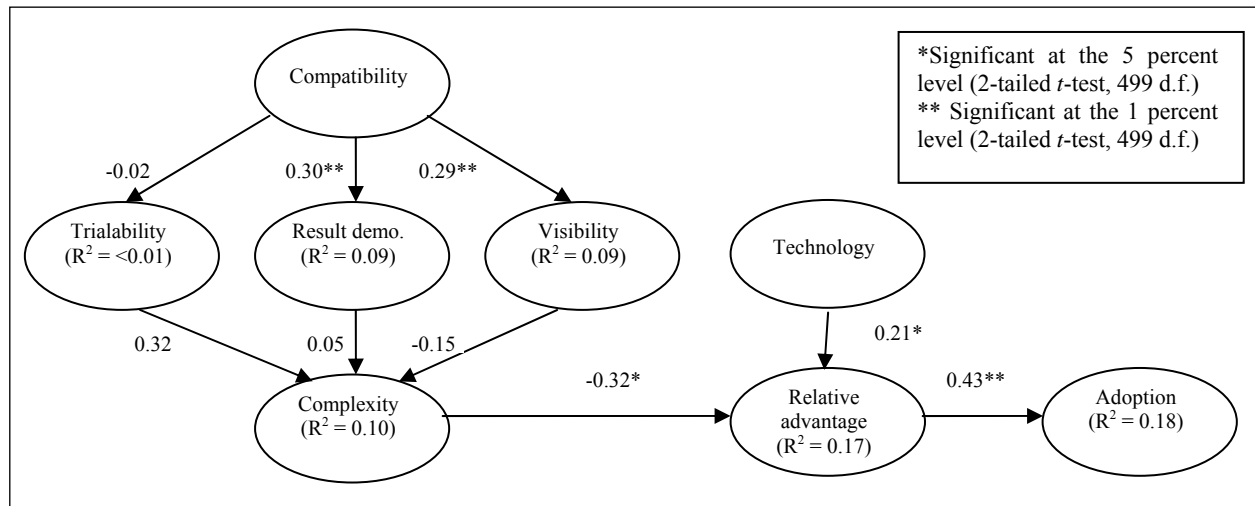
Figure 4.2 shows the results for the original structural model. The path coefficients were tested for significance using student *t*-statistics generated by bootstrap resampling with 500 subsamples (Chin, 1998). The results support the hypothesis that relative advantage affects the extent of cluster adoption (proposition 7). Access to resources that are relatively more valuable,

⁴ These statistics are available, however, from the author on request.

⁵ Note that RA4, RD2, RD3, and V1 did not have many not-applicable responses but did have low loadings. RA4 and RD3 also had higher cross-loadings.

immobile, and heterogeneous does positively influence the extent of cluster adoption. The R^2 for adoption, however, is only 18 percent, lower than other innovation diffusion studies. The lower R^2 could be the result of using a more precise measure of relative advantage.

Figure 4.2: Structural model of cluster adoption



The results also support the relationships between relative advantage and complexity and relative advantage and technology (propositions 5 and 6). The negative significant relationship between complexity and relative advantage supports the conclusion that a perception of clustering as being difficult reduces relative advantage. Despite the close geographic proximity of cluster members, the results indicate that communication technologies such as the web, e-mail, and intranets are still important for obtaining cluster benefits. The remaining hypotheses are not supported. There are significant paths between compatibility \rightarrow result demonstrability and compatibility \rightarrow visibility but in the opposite direction to that hypothesized. One explanation is that previous experience with successful clusters still requires additional reinforcement through visibility and result demonstrability.⁶ There are no significant paths to complexity so the revised model includes a direct path from compatibility to complexity.

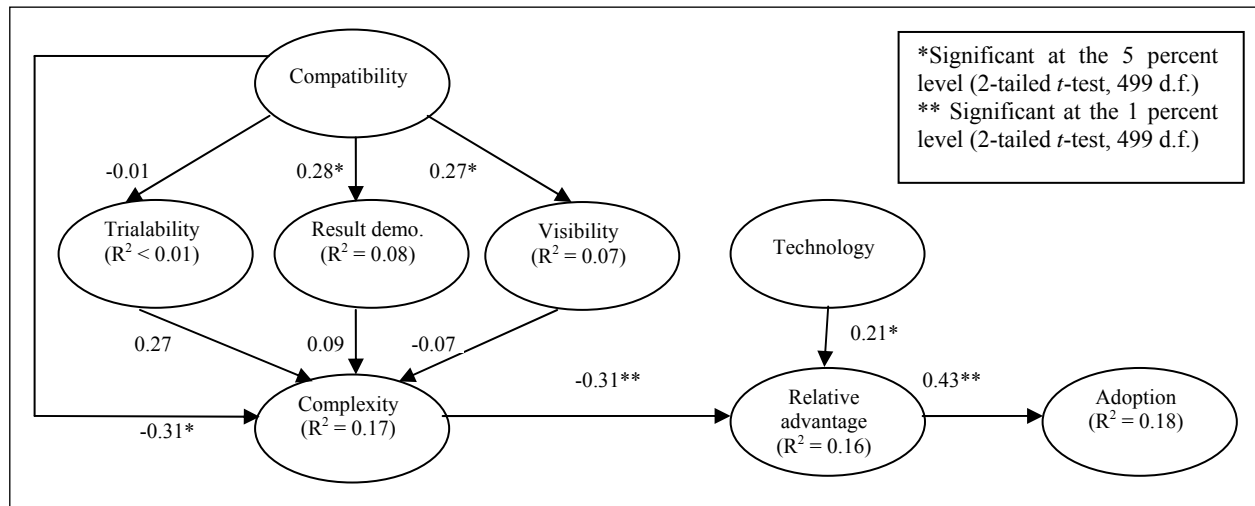
4.4.1 Revised Model

Figure 4.3 presents the revised model suggested by the results discussed above. The path from compatibility to complexity is significant, indicating that previous experiences with clusters

⁶ A sensitivity analysis examined the traditional relationships of the diffusion constructs – namely, that each construct directly and independently affects adoption. Paths were added from compatibility, complexity, result demonstrability, and visibility to adoption. The results do not support the traditional model. None of the direct paths are significant.

reduce the perception that clustering is complex. The previous experiences possibly allow cluster members to better anticipate any difficulties in participating in the cluster. The other results are consistent with the original model.

Figure 4.3: Revised model of cluster adoption



5. LIMITATIONS AND CONCLUSIONS

This paper developed and tested a model of cluster adoption. The resource-based view of the firm identified resource characteristics that provided a more-refined measure of relative advantage. Innovation diffusion theory provided constructs that helped explain cluster adoption.

5.1 Limitations

Construct validity is threatened by the use of varying questions to account for the respondent's current stage in the adoption process. While this technique improves construct validity because respondents do not have to interpret the question to fit their current situation, it is threatened because even slight changes in the questions may alter their meaning. The consistency of results across the Internet and paper-based surveys suggests, however, that this limitation had little impact, if any, on the results.

There is an external validity threat that the results may not be replicable in other countries due to differing government, economic, and social conditions. Another external-validity threat is that the findings may only apply to clusters supported by government intervention. The mitigating factor for most clusters was that most were selected for government assistance because there was already the beginning of natural cluster development. Another external validity threat is a consequence of non-response and self-selection bias. Most survey

respondents were current cluster members. The other survey respondents were either past members or businesses considering cluster adoption. Most survey respondents may therefore be predisposed to cluster adoption and the results may not extend to non-adopters.

The main threat to reliability is misinterpretation of questions by respondents. A number of concepts used in the survey are difficult to understand and may be interpreted differently by respondents. This threat was mitigated by providing pop-up examples on the Internet survey and by adapting the questions to the respondent's current situation. These features were not available to respondents who elected to complete the paper-based survey. The consistency of results across both survey methods suggests that this limitation did not substantially affect the results.

The final limitation is the possibility of omitted correlated variables. For example, some studies on adoption also include normative beliefs in addition to the innovation attributes (Karahanna et al., 1999; Tan and Teo, 2000). Normative beliefs are those beliefs held by the potential adopter as a result of social pressure or the need for approval. Most organizations that are cluster participants or potential cluster participants are small firms, so social approval is unlikely to be relevant to the adoption decision because the firms are managed by single owners with no peers inside the firm. Parsimony is another reason for not including normative beliefs in the research model. This assumption was confirmed by interviews with cluster members. The omission of normative beliefs remains, however, a limitation of the research.

5.2 Conclusions

This paper examined factors that affect cluster adoption. Relative advantage has a positive effect on the extent of cluster adoption (proposition 7). This result suggests that resource attributes derived from the resource-based view of the firm (value, immobility, and heterogeneity) are an important measure of cluster relative advantage. Relative advantage is affected directly by complexity and use of technology for cluster coordination (propositions 5 and 6). The cluster is more likely to provide a relative advantage if cluster participation is perceived as less complex and if e-mail, web, and intranet technologies are used to coordinate the cluster. The revised model investigated a direct relationship between compatibility and complexity. There is a negative relationship between compatibility and complexity, indicating that previous experience with clusters reduces perceived complexity.

Compatibility was found to be positively associated with result demonstrability and visibility (propositions 1b and 1c). These results were in the opposite direction to that

hypothesised. Result demonstrability, visibility, and trialability, however, were not associated with complexity as predicted. This finding reinforces previous diffusion research that reports relative advantage, compatibility, and complexity are the most important diffusion attributes.

This paper has implications for Porter's cluster theory (Porter, 2000). It takes the broad theory suggested by Porter and analyzes clustering at the resource and transaction level. This research also attempted to further develop our knowledge of the relationships amongst the diffusion attributes. This paper provides support for the implication that the diffusion constructs do not simply affect adoption directly but also affect the other diffusion attributes. The research builds on earlier diffusion research that has found relative advantage to be the most important factor in cluster adoption (Tornatzky and Klein, 1982). This research will hopefully aid potential cluster members, cluster consultants, and government agencies to determine when clustering will benefit a group of organizations. It provides guidance for consultants in determining those transactions on which to focus.

One avenue of future research is to further investigate the interrelationships of the diffusion constructs and their measurement. Research is necessary to assess the relative contributions of the diffusion constructs in explaining adoption. My future research agenda includes applying the diffusion sections of the model to different innovations, especially more pure technological innovations. A more narrowly defined innovation may place different emphases on the diffusion constructs. Another avenue for future research is to apply the model to more naturally occurring clusters (i.e., those clusters that have developed without government assistance).

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